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DIAPHRAGM PUMP

The invention relates to a diaphragm pump comprising a working diaphragm that, during pumping movements, oscillates between a bottom dead center and a top dead center. The working diaphragm delimits a pump chamber between itself and a preferably concave pump chamber wall and when located at the top dead center position, the working diaphragm rests against the pump chamber wall.

Diaphragm pumps of the type named above are already known in various configurations. If such diaphragm pumps are operated in the lower vacuum range, there is the risk that the working diaphragm will bulge due to differences in the pressure loads occurring between the top side and the lower side of the diaphragm and therefore will reduce the suction chamber volume. Even in this lower vacuum range, large pressure differences occur between the top side and the lower side of the diaphragm. While atmospheric pressure usually applies a load on the lower side of the diaphragm, the corresponding evacuation pressure acts on the top side of the diaphragm, wherein the maximum pressure difference is given by the atmospheric pressure minus the limiting pressure of the diaphragm pump.

In typical diaphragms of conventional diaphragm pumps, especially when these diaphragm pumps operate within the range of the limiting pressure and large differences in pressure loads are applied to the diaphragms, it is to be emphasized that the lateral, elastic zone of the flexible diaphragm bulges in the direction towards the feeding chamber due to the atmospheric pressure. This "bulging" of the diaphragm leads to the result that the suction chamber volume is reduced considerably, which has a negative effect on the suction capacity of diaphragm pumps.

This change in shape is especially pronounced in two-stage and multi-stage diaphragm pumps with low limiting pressures. In these pumps, the lowest vacuum stage is affected the most, because the greatest pressure differences occur here.

Therefore, the objective arises of designing a diaphragm pump of the above-noted type, which, even in the event of differences in pressure loads occurring between the top side and the lower side of the diaphragm, tends neither to increase the total chamber volume nor to reduce the suction chamber volume.

According to the invention, the solution to meeting this objective is provided especially in that, for the diaphragm pump of the above-noted type, the working diaphragm has an inner and an outer annular zone, which can be deformed during the pumping movements, and in that a stiffened diaphragm area, which essentially cannot be deformed during the pumping movements, is placed between these annular zones.

The diaphragm pump according to the invention has a working diaphragm, which has an inner and an outer annular zone, wherein a stiffened diaphragm area, which cannot be deformed during the pumping movements, is placed between these annular zones. While the inner and the outer annular zone form two hinge areas, which permit the bending of the working diaphragm required by the stroke in these areas, the non-deformable diaphragm area lying in-between acts against an undesired and performance-reducing bulging of the working diaphragm at increased differences in pressure loads. Here, the diaphragm is stiffened in its non-deformable diaphragm area, such that the working diaphragm nevertheless rests unimpaired against the preferably concave pump chamber wall at the top dead center.

The diaphragm can be stiffened in the deformable diaphragm area bordered by the inner annular zone and the outer annular zone, for example, by a stiffening diaphragm insert. However, a preferred embodiment according to the invention provides that the working diaphragm is stiffened in its non-deformable diaphragm area by means of support ribs, which are oriented in the radial direction, which are spaced apart from each other in the circumferential direction, and which are arranged on the lower side of the diaphragm facing away from the pump chamber wall.

A working diaphragm, which has such stiffening support ribs on the lower side of its diaphragm facing away from the pump chamber wall, can be formed at least in its non-deformable diaphragm area from a single material layer. In this way, the support or stiffening ribs are embodied geometrically and dimensioned, such that, for example, even for low limiting pressures, the atmospheric pressure prevailing during the suction stroke on the lower side of the diaphragm, cannot bend the diaphragm in its non-deformable diaphragm area. The support ribs stiffening this diaphragm area are delimited on both sides by the deformable annular zones, which form the hinge areas required for the flexing movements of the diaphragm during the pumping movements.

The support ribs can be arranged in the radial direction on the lower side of the diaphragm. However, the greater the angle of the support ribs to the radial lines, the smaller the radial deformation of the support ribs and the deformation of the contours of the ribs facing the compression chamber associated with an increase in the dead space as well as with a reduction of the final vacuum. Here, a refinement according to the invention provides that the support ribs have a curved longitudinal extent and thus are arranged practically in a spiral on the lower side of the diaphragm.

In contrast, if the ribs have a straight longitudinal extent, it can be advantageous if the support ribs deviate from the radial lines preferably up to ±30°.

Here, it is useful if the support ribs spaced apart from each other in the circumferential direction have the same direction of curvature or deviation from the radial lines.

So that a working diaphragm with a uniform thickness in its non-deformable diaphragm area can also rest well especially against the preferably concave pump chamber wall, it is advantageous if the side of the support ribs facing the pump chamber wall is fitted to the contours of the pump chamber wall shape.

Additional features of the invention will be understood from the following description of embodiments according to the invention in connection with the claims as well as the drawing. The individual features can be reduced to practice individually or in combinations for an embodiment according to the invention.

Shown in schematic representation are:

Figure 1 a view of the working diaphragm of a diaphragm pump at the topr dead center of its pumping movements, wherein the working diaphragm has two annular zones, which act as deformable hinge areas and between which a non-deformable diaphragm area stiffened by means of support ribs is arranged,

Figure 2 is a view of the working diaphragm from Figure 1 at the bottom dead center of its pumping movements,

Figure 3 a lower side view of the diaphragm of a working diaphragm comparable with Figure 1, and

Figure 4 a lower side view of the working diaphragm from Figures 1 to 3 in a modified embodiment.

In Figures 1 and 2, a diaphragm pump 1 is shown in the region of its pump head 2. The diaphragm pump 1 has a working diaphragm 3, which is tensioned at its peripheral edge in the pump head. In the working diaphragm 3, a central attachment core 4 is formed, which is connected to the connecting member 5 of a crank drive not shown in more detail here. The working diaphragm 3 oscillating between the top dead center shown in Figure 1 and the bottom dead center shown in Figure 2 during the pumping movements , and delimits a pump chamber 7 between itself and a concave pump chamber wall 6.

Especially if the diaphragm pump 1 shown here, for example, as a fore-pump of a turbo molecular pump, operates in lower vacuum ranges, large pressure differences occur between the top side and the lower side of the diaphragm. So that the working diaphragm 3 does not bulge due to the differences in pressure loads occurring between the top side and the lower side of the diaphragm and so that therefore the suction chamber volume is not reduced significantly, the working diaphragm 3 has a stiffened annular zone that is essentially non-deformable during the pumping movements. This non-deformable diaphragm area is delimited by an inner annular zone 8 and an outer annular zone 9, which are used as deformable hinge areas during the pumping movements.

For stiffening the diaphragm in its non-deformable diaphragm area, there are support ribs 10, which are oriented here in the radial direction and which are arranged on the lower side of the diaphragm facing away from the pump chamber

wall 6. These support ribs 10 are spaced apart from each other at uniform intervals in the circumferential direction. So that the working diaphragm 3 - as Figure 1 shows - can rest against the pump chamber wall 6 preferably over its entire surface in the top dead center, the side of the support ribs 10 facing the pump chamber wall 6 is adapted in shape to the contours of the pump chamber wall 6.

As shown in Figure 3, the support ribs 10 can have a straight longitudinal extent. In order to support the stiffening of the working diaphragm 3 in the non-deformable annular zone, it can be advantageous if the support ribs 10 deviate from the radial lines preferably by up to ±30°. However, it is also possible that the support ribs - as shown in Figure 4 - have a curved longitudinal extent and are arranged practically in a spiral on the lower side of the diaphragm.

The greater the angle of the support ribs 10 shown in Figures 3 and 4 to the radial lines, the smaller the radial deformation of the support ribs 10 and the deformation of the contours of the support ribs 10 facing the compression or pump chamber 7, which is associated with an increase in the dead space, as well as with a reduction of the final vacuum.